Case Study 2: Pediatric Heart Surgery Mortality

As the result of a recent *New York Times* expose, UNC Hospital recently suspended most of its complex pediatric cardiovascular surgical procedures. Most hospitals participate in voluntary public reporting through the Society for Thoracic Surgeons (STS) Congenital Heart Surgery Database. At the time of the last report, roughly 85% of programs participated in this voluntary reporting. Data are made available over 4-year analytic time windows in each annual report. Note that due to periodic data updates, the data we have may differ slightly from the data available online, either on the STS website or on individual hospital websites.

While UNC did not participate in this program at the time of the expose, they eventually posted 2015-2018 mortality data online. The data on neonates+infants+children is comparable to the data we will consider from the STS database.

The data we have includes the number of pediatric (neonates+infants+children) surgical procedures during the 2015-2018 reporting period and the number of deaths resulting from those procedures. An important aspect of evaluating hospital performance in pediatric surgery is the consideration of the *case mix* of each hospital. In particular, highly ranked programs may attract the more severely diseased patients, leading to a more challenging group of procedures and higher mortality. In order to account for the difficulty of the *case mix*, the data contain a hospital-specific expected mortality rate for procedures in each of 5 categories, in which category 1 represents the simplest procedures (which should have the lowest mortality), and category 5 represents the most challenging procedures associated with the highest mortality. You can read more about specific procedures included in each category here. Because there is significant potential for variation in difficulty of procedures even within a category, the expected mortality rate is provided separately for each category and hospital based on the individual patients seen by that hospital during the time period of interest.

One common performance metric is the ratio of observed to expected (O to E) mortality rates, accompanied by a 95% interval estimate. Ratios significantly higher than 1 indicate hospitals with significantly more deaths than expected, while ratios < 1 indicate the better-performing hospitals. You can see in the UNC data that mortality rates were quite high there relative to expectations for the more complex procedures.

The STS rates each hospital by providing a star rating as follows:

- one star: higher than expected operative mortality; the 95% confidence interval (CI) for a participant's risk-adjusted O/E mortality ratio was entirely above the number 1
- two stars: as expected operative mortality; the 95% CI for a participant's risk-adjusted O/E mortality ratio overlapped with the number 1
- three stars: lower than expected operative mortality; the 95% CI for a participant's risk-adjusted O/E mortality ratio was entirely below the number 1

An alternative star method, used for adult procedures, awards three stars if the posterior probability that the hospital's mortality ratio exceeds the STS mean is 0.975 or greater, one star if the posterior probability that the hospital's mortality ratio exceeds the STS mean is 0.025 or lower, and two stars otherwise.

Your job is to investigate mortality rates, both overall and stratified by procedure complexity, for the hospitals represented in the data (UNC should be added by you to the data file provided). Discuss the advantages of hierarchical modeling in this setting. You may find the ideas in George et al paper to be quite useful in formulating a reasonable modeling approach.

You should provide estimated star ratings as well as point and interval estimates of each facility's O/E mortality ratio. Provide a ranking (and accompanying justification) of the top and bottom 10 hospitals for children's (neonates+infants+children) cardiovascular surgery, and discuss whether the attention directed to UNC's program appears to be justified by the data.

The data from 2015-2018 are on Sakai in the file cardiomort.RData and contain the following variables.

- id: unique hospital identifier
- Hospital Name
- Procedure Type: overall (mortality for all procedures), STAT mortality category 1 (generally the lowest risk procedures) through STAT mortality category 5 (generally the highest risk procedures)
- Observed deaths
- Total procedures (observed deaths/total procedures is the observed mortality rate)
- Expected mortality rate (this mortality rate is adjusted to reflect the individual case mix in the procedure type of interest for the hospital of interest)

UNC data are not included in this file; you will need to append them to the dataset based on the values available online (see link above).

Your write-up should be limited to 8 pages in 11 point font (or larger) including any tables and figures (reproducible R code for all analyses is not included in the 8 page limit). NOTE: some .pdf conversions reduce font; points will be deducted if the font is not 11 point when your report is printed. Your write-up should specify the statistical model used, including the data model and prior distributions (if relevant), in addition to communicating your analysis findings. Both the write-up and code will be submitted via upload to Sakai by the group.